

## DESCRIPTION

**A RADIO COMMUNICATION SYSTEM, METHOD OF OPERATING A  
COMMUNICATION SYSTEM, AND A MOBILE STATION**

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The invention relates to a radio communication system, a method of operating a communication system, and a mobile station for use in a communication system.

10 In a radio communication system comprising base stations of fixed location and mobile stations, transmissions from a base station to a mobile station take place on a downlink channel and transmissions from a mobile station to a base station take place on an uplink channel. It is known to use downlink closed loop transmit power control in which a mobile station  
15 measures the quality of a received power controlled downlink pilot signal and transmits transmit power control (TPC) commands to a base station so that an adequate, but not excessive, received signal level is maintained at the mobile station despite fluctuations in downlink channel conditions. It is also known to use uplink closed loop transmit power control in which a base station  
20 measures the quality of a received uplink pilot signal and transmits transmit power control (TPC) commands to a mobile station so that an adequate, but not excessive, received signal level is maintained at the base station despite fluctuations in uplink channel conditions.

When a plurality of mobile stations share a channel, separate TPC  
25 commands are provided for each active mobile station because each mobile station will experience unique channel fluctuations. Similarly, a separate downlink pilot signal is provided for each active mobile station; each mobile station demodulates its respective pilot signal to estimate the channel characteristics prevailing for that mobile station and optionally to generate a phase reference. The estimated channel characteristics and the phase  
30 reference are then used to assist demodulating information carrying signals.

The pilot signals comprise predetermined data values to enable a mobile station readily to determine distortion introduced by the channel.

The pilot signals and the signals conveying the TPC commands are subject to transmit power control.

5       The transmission of the pilot signals and the TPC commands uses system resources. For example, in a Code Division Multiple Access (CDMA) system channel codes are required for the pilot signals and TPC commands, and in a Time Division Multiple Access (TDMA) system time slots are required for the pilot signals and TPC commands.

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An object of the invention is to reduce the requirement for system resources.

According to a first aspect of the invention there is provided a mobile station for use in a communication system having a base station, the mobile station comprising:

15       receiver means for receiving from the base station a first downlink signal, measurement means for measuring a parameter of the received first downlink signal;

20       power control means for generating first power control commands in response to the measured parameter; and

transmitter means for transmitting the first power control commands to the base station;

wherein the measurement means is adapted to measure the parameter of the first downlink signal while first downlink signal is modulated with non-

25       predetermined data values and is subjected to transmit power control in accordance with the first power control commands.

According to a second aspect of the invention there is provided a radio communication system comprising a base station and at least one mobile station in accordance with the first aspect of the invention.

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According to a third aspect of the invention there is provided a method of operating a communication system comprising a base station and at least one mobile station, comprising

at the base station, receiving first power control commands transmitted by the mobile station and transmitting a first downlink signal modulated with non-predetermined data values and subjected to transmit power control in accordance with the first power control commands, and

at the mobile station, receiving the first downlink signal, measuring a parameter of the first downlink signal modulated with the non-predetermined data values, generating the first power control commands in response to the measured parameter, and transmitting the first power control commands.

The invention is based on the realisation that downlink closed loop power control may be operated by measuring the quality of received downlink non-predetermined data symbols instead of predetermined pilot symbols, and that in some circumstances, separate downlink pilot signals for each active mobile station are not necessary for channel estimation. In some circumstances, downlink channel estimation is not required at all, and in other circumstances a common downlink pilot signal transmitted at a constant power level may be used instead of separate pilot signals. Consequently, operation is possible using fewer downlink system resources.

Optionally, the non-predetermined data values used for measuring the quality of a received signal for downlink closed loop power control may convey downlink TPC commands used for uplink power control.

The invention will now be described, by way of example only, with reference to the accompanying drawings wherein:

Figure 1 is a block schematic diagram of a communication system; and  
Figure 2 is flow chart of a method of operating a communication system.

One application for the invention is in the Universal Mobile Telecommunication System (UMTS). In the UMTS Frequency Division Duplex (FDD) mode, in Release 5 of the UMTS Specifications which may be viewed

at <http://www.3gpp.org>, it is possible to operate High Speed Downlink Packet Access (HSDPA) in such a way that a downlink dedicated channel is not needed for data (user or signalling), as data can be sent via the High Speed Downlink Shared Channel (HS-DSCH). A dedicated channel uses a single  
5 channel code for exactly one user, while a shared channel allows a plurality of users to share a single channel code, either simultaneously, or in rapid time multiplex. Even though data can be sent via a shared channel, a downlink Dedicated Channel (DCH) is still required for transmitting TPC commands for each active mobile station, in order to control the uplink transmit power.

10 The existence of a downlink DCH requires the allocation of a channel code for the duration of the connection. One way of operating the downlink DCH is to configure it as a fractional DCH which comprises only pilot symbols and TPC commands, with multiple users multiplexed on to the same channel code in such a way that each user uses the channel code for only a fraction of  
15 each timeslot. Signalling is used to assign mobile stations to use a particular channel code and fraction of a timeslot, in order to align the uplink and downlink power control timing. Such a scheme frees up channel codes which can be used to increase system capacity. However the present invention requires even fewer resources.

20 The requirement is for the mobile station to be able to derive a power control command to send in the uplink. This will then be used by the base station to adjust the power of the part of the fractional DCH corresponding to that mobile station.

The invention is based on the recognition that separate pilot symbols for  
25 each active mobile station are not necessary in at least two cases:

- 1) Where the transmitted phase of the DCH is referenced to that of a common pilot signal, for example by using the same antenna(s) and antenna weights for both the DCH and the common pilot signal to which the phase of the DCH is referenced. In this case the characteristics of the radio channel  
30 can be estimated from the common pilot signal and this estimate can be used to demodulate the TPC bits.

This first case is very likely to apply in HSDPA, as the HS-DSCH will be assigned a common pilot signal as a reference and the same common pilot signal can be used for the fractional DCH. Since the total power used by fractional DCH's is not likely to be very large, the benefits of separate antenna beamforming for fractional DCH will not be large.

2) Where different antennas or antenna weights are used for the common pilot signal and the DCH, but the correlation between them is sufficiently good that the common pilot signal can be used to make a reasonable channel estimate for the DCH, such that the data on the DCH can be received reliably.

So, in accordance with the invention the downlink fractional DCH can consist only of non-predetermined information bits multiplexed between users. A special case of particular interest is where these information bits carry TPC commands. The amplitude of individual TPC bits may be adjusted by the base station according to power control commands received from the relevant mobile station. The mobile station determines the radio channel phase characteristics from an appropriate common pilot signal, demodulates the TPC commands, and increases or decreases the mobile station uplink DPCCH power as required. In addition, the mobile station uses the amplitude of the received TPC bits to determine any TPC commands sent in the uplink.

Figure 1 is a block schematic diagram of a communication system comprising a base station 100 and a mobile station 200. In practice there would be a plurality of mobile stations 200, but for clarity only a single mobile station 200 is illustrated.

The mobile station 200 comprises a receiver 220 coupled to an antenna 210 for receiving radio signals transmitted by the base station 100. Coupled to an output of the receiver 220 is a measurement means 250 for measuring a parameter of a signal received from the base station 100. The measurement means 250 is adapted to measure the parameter of a signal which is modulated with non-predetermined data and is subjected to transmit power control by the base station 100. An output of the measurement means 250 is coupled to a first input of a power control means 230. The power control means 230 comprises a generation means (TPC 1) 232 for generating first

TPC commands in response to the parameter measured by the measurement means 250. A first output of the power control means 230 is coupled to a first input 244 of a transmitter 240 for transmitting the first TPC commands via the antenna 210 to the base station 100.

5       The base station 100 comprises a transmitter 140 and a receiver 120 coupled to an antenna 110. The receiver 120 receives radio signals transmitted by the mobile station 200, in particular the first TPC commands. An input of a power controller (PC) 130 is coupled to an output of the receiver 120 for decoding the first TPC commands received from the mobile station  
10       200, and a first output of the power controller 130 is coupled to a first input 142 of the transmitter 140 for controlling the transmit power of the transmitter 140 in accordance with the first TPC commands.

Optionally, at the base station 100, the power controller 130 measures the quality of a signal received from the mobile station 200 and, in response to  
15       the measured quality, generates second TPC commands. A second output of the power controller 130 is coupled to a second input 144 of the transmitter 140 for transmission of the second TPC commands to the mobile station 200, to control the transmit power of the mobile station 200.

Optionally, at the mobile station 200, the power control means 230 is  
20       coupled to an output of the receiver 220 and comprises a decoding means (TPC 2) 234 for decoding the second TPC commands. A second output of the power control means 230 is coupled to a second input 242 of the transmitter 240 for controlling the transmit power of the transmitter 240 in accordance with the second TPC commands. In this case, the non-predetermined data on  
25       which the measurement means 250 makes its measurement may be the second TPC commands.

Referring to Figure 2, steps on the left hand side of the flow chart relate to steps performed at the base station 100, and steps on the right hand side of the flow chart relate to steps performed at the mobile station 200.

30       At step 310 the base station 100 receives first TPC commands from the mobile station 200.

At step 320 the base station 100 transmits to the mobile station 200 a signal modulated with non-predetermined data values and subjected to transmit power control in accordance with the first TPC commands.

At step 330 the mobile station 200 receives the signal modulated with  
5 the non-predetermined data values.

At step 340 the mobile station 200 measures a parameter of the signal modulated with the non-predetermined data values.

At step 350 the mobile station 200 generates the first TPC commands in response to the measured parameter.

10 Optionally, at step 360, the non-predetermined data values may comprise second TPC commands and the mobile station 200 may decode the second TPC commands, and at step 370 the mobile station may control its transmit power in accordance with the second TPC commands.

At step 380 the mobile station 200 transmits the first TPC commands  
15 generated at step 350.

Flow then reverts to step 310 and the process continues to loop. The signal parameter measured by the measurement means 250 of Figure 1, and at step 340 of Figure 2, may be, for example, any of: signal to noise ratio; signal to interference ratio;  $E_b/N_0$  (where  $E_b$  is energy per bit and  $N_0$  is noise  
20 density).

The decision threshold for TPC commands sent in the uplink can be determined by setting a particular error rate requirement for the TPC commands received in the downlink. This is in contrast to current practice which is to set a decision threshold in terms of the signal to noise ratio required  
25 to meet a predetermined performance target, for example a frame error rate of a data channel. One application for the invention is a fractional control channel in UMTS FDD (frequency division duplex) mode. With a spreading factor of 256 there are 10 symbols per slot. Therefore one slot can conveniently support either 2, 5 or 10 users with 5, 2 or 1 symbol per TPC  
30 command respectively.

In another application of the invention in UMTS the spreading factor would be 128, which would support the use of Space Time Transmit Diversity

(STTD) applied to groups of two symbols. In this case, there are 20 symbols per slot, so 10 users can be supported while still maintaining the 2 symbols per TPC command which are required for the STTD encoding process.

Optionally, by avoiding the need to transmit a separate pilot signal for  
5 each user, the energy that would have been used to transmit the separate pilot signals may be redeployed by increasing the number of symbols used to transmit the TPC commands, thus improving the reliability of the TPC commands.

In the present specification and claims the word "a" or "an" preceding an  
10 element does not exclude the presence of a plurality of such elements. Further, the word "comprising" does not exclude the presence of other elements or steps than those listed.

From reading the present disclosure, other modifications will be  
apparent to persons skilled in the art. Such modifications may involve other  
15 features which are already known in the art of mobile communications and which may be used instead of or in addition to features already described herein.